



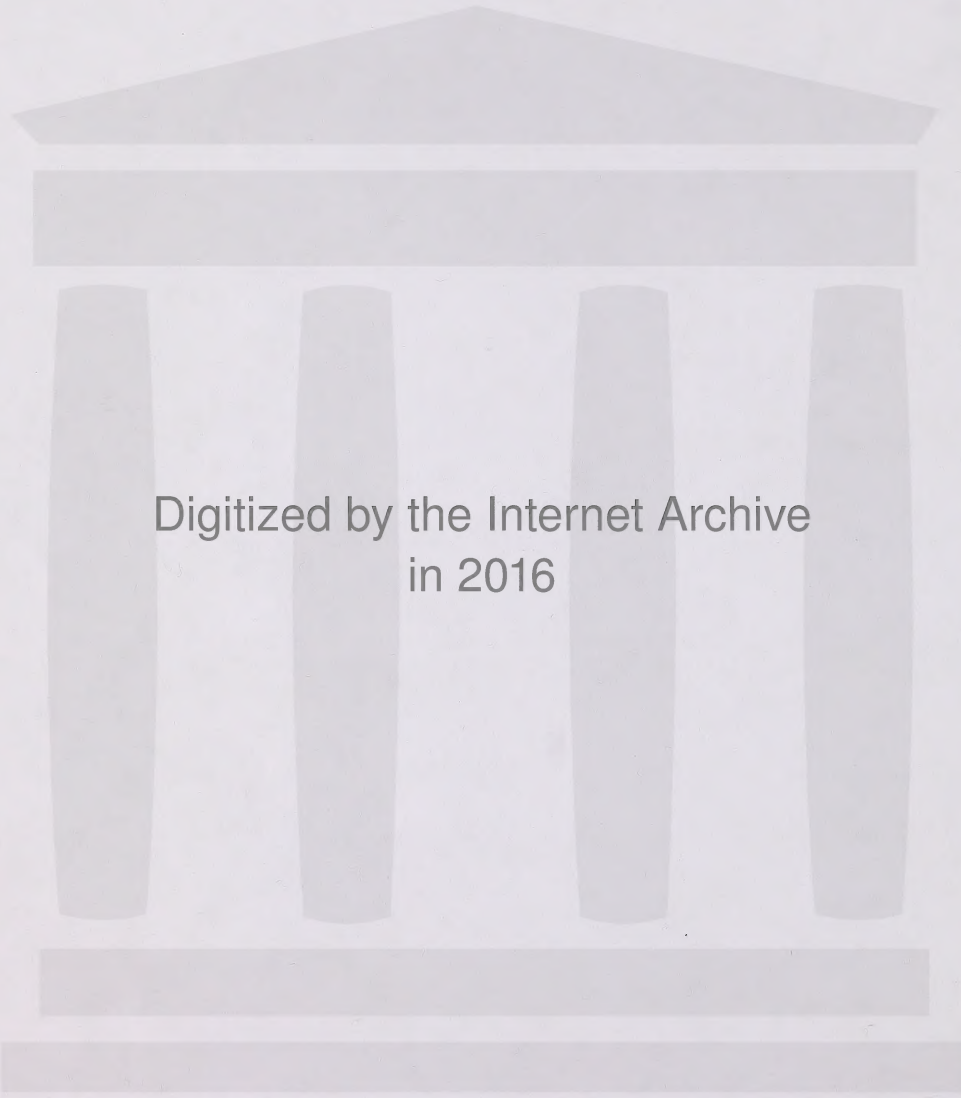
Students

First!

Student Evaluation

CHEMISTRY
DATA BOOKLET
(Revised 1990)

Alberta
EDUCATION

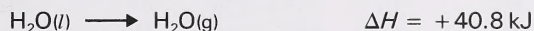
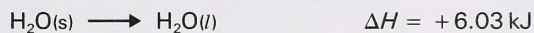


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CHEMISTRY

MISCELLANEOUS



Room temperature = 298.15 K (25°C)

Standard pressure = 101 kPa

The Avogadro number = $6.02 \times 10^{23}/\text{mol}$

Ion product for water = $1.0 \times 10^{-14} \text{ mol}^2/\text{L}^2$

Specific heat capacities:

$$\text{H}_2\text{O(s)} = 2.01 \text{ J/(g}\cdot^\circ\text{C)}$$

$$\text{H}_2\text{O(l)} = 4.19 \text{ J/(g}\cdot^\circ\text{C)}$$

$$\text{H}_2\text{O(g)} = 2.01 \text{ J/(g}\cdot^\circ\text{C)}$$

Speed of light = $3.00 \times 10^8 \text{ m/s}$

Charge of 1.00 mol of electrons = $9.65 \times 10^4 \text{ C}$

MELTING AND BOILING POINTS, AND SPECIFIC HEAT CAPACITY OF MOST ELEMENTS

NAME	SYMBOL	#	MELTING POINT (°C)	BOILING POINT (°C)	SPECIFIC HEAT* CAPACITY (J/g·°C)
aluminum	Al	13	660	2467	0.900
antimony	Sb	51	631	1750	0.205
argon	Ar	18	-189	-186	0.519
barium	Ba	56	725	1640	0.192
beryllium	Be	4	1278	2970	1.824
bismuth	Bi	83	271	1560	0.124
boron	B	5	2079	2550	1.025
bromine	Br	35	-7	59	0.473
cadmium	Cd	48	321	765	0.232
calcium	Ca	20	839	1484	0.653
cerium	Ce	58	798	3443	0.205
cesium	Cs	55	28	669	0.238
chlorine	Cl	17	-101	-35	0.477
chromium	Cr	24	1857	2672	0.448
cobalt	Co	27	1495	2870	0.456
copper	Cu	29	1083	2567	0.385
dysprosium	Dy	66	1412	2567	0.173
erbium	Er	68	1529	2868	0.168
europium	Eu	63	822	1527	0.176
fluorine	F	9	-220	-188	0.824
gadolinium	Gd	64	1313	3273	0.230
gallium	Ga	31	30	2403	0.372
germanium	Ge	32	937	2830	0.322
gold	Au	79	1064	2808	0.129
helium	He	2	-272	-269	5.188
holmium	Ho	67	1474	2700	0.164
hydrogen	H	1	-259	-253	14.267
indium	In	49	157	2080	0.234
iodine	I	53	114	184	0.427
iridium	Ir	77	2410	4130	0.133
iron	Fe	26	1535	2750	0.444
krypton	Kr	36	-157	-152	0.247
lanthanum	La	57	918	3464	0.197
lead	Pb	82	328	1740	0.159
lithium	Li	3	181	1342	3.556
lutetium	Lu	71	1663	3402	0.155
magnesium	Mg	12	649	1090	1.017
manganese	Mn	25	1244	1962	0.477
mercury	Hg	80	-39	357	0.138
molybdenum	Mo	42	2617	4612	0.251

* for room temperature state

MELTING AND BOILING POINTS, AND SPECIFIC HEAT CAPACITY OF MOST ELEMENTS (continued)

NAME	SYMBOL	#	MELTING POINT (°C)	BOILING POINT (°C)	SPECIFIC HEAT* CAPACITY (J/g°C)
neodymium	Nd	60	1021	3074	0.205
neon	Ne	10	-249	-246	1.029
nickel	Ni	28	1453	2732	0.444
niobium	Nb	41	2468	4742	0.268
nitrogen	N	7	-210	-196	1.042
osmium	Os	76	3045	5027	0.131
oxygen	O	8	-218	-183	0.916
palladium	Pd	46	1554	3140	0.244
phosphorus	P	15	44	280	0.757
platinum	Pt	78	1772	3827	0.133
polonium	Po	84	254	962	0.126
potassium	K	19	63	760	0.753
praseodymium	Pr	59	931	3520	0.192
radium	Ra	88	700	1140	0.120
radon	Rn	86	-71	-62	0.094
rhenium	Re	75	3180	5627	0.138
rhodium	Rh	45	1965	3727	0.244
rubidium	Rb	37	39	686	0.360
ruthenium	Ru	44	2310	3900	0.238
samarium	Sm	62	1074	1794	0.180
scandium	Sc	21	1541	2836	0.556
selenium	Se	34	217	685	0.321
silicon	Si	14	1410	2355	0.703
silver	Ag	47	962	2212	0.237
sodium	Na	11	98	883	1.226
strontium	Sr	38	769	1384	0.301
sulphur	S	16	113	445	0.732
technetium	Tc	43	2172	4877	0.243
tellurium	Te	52	450	990	0.201
terbium	Tb	65	1356	3230	0.183
thallium	Tl	81	303	1457	0.128
thulium	Tm	69	1545	1950	0.160
tin	Sn	50	232	2270	0.213
titanium	Ti	22	1660	3287	0.523
tungsten	W	74	3410	5660	0.133
uranium	U	92	1132	3818	0.115
vanadium	V	23	1890	3380	0.485
xenon	Xe	54	-112	-107	0.158
ytterbium	Yb	70	819	1196	0.145
yttrium	Y	39	1522	3338	0.285
zinc	Zn	30	420	907	0.388
zirconium	Zr	40	1852	4377	0.281

* for room temperature state

STANDARD HEATS OF FORMATION AT 298.15 K (25°C)

NAME	FORMULA	ΔH_f° (kJ/mol)
aluminum oxide	$\text{Al}_2\text{O}_3(\text{s})$	- 1675.7
ammonia	$\text{NH}_3(\text{g})$	- 46.1
ammonium chloride	$\text{NH}_4\text{Cl}(\text{s})$	- 314.4
ammonium nitrate	$\text{NH}_4\text{NO}_3(\text{s})$	- 365.6
barium carbonate	$\text{BaCO}_3(\text{s})$	- 1216.3
barium chloride	$\text{BaCl}_2(\text{s})$	- 858.6
barium hydroxide	$\text{Ba}(\text{OH})_2(\text{s})$	- 944.7
barium oxide	$\text{BaO}(\text{s})$	- 553.5
barium sulphate	$\text{BaSO}_4(\text{s})$	- 1473.2
benzene	$\text{C}_6\text{H}_6(\text{l})$	+ 49.0
butane	$\text{C}_4\text{H}_{10}(\text{g})$	- 126.5
calcium carbonate	$\text{CaCO}_3(\text{s})$	- 1206.9
calcium chloride	$\text{CaCl}_2(\text{s})$	- 795.8
calcium hydroxide	$\text{Ca}(\text{OH})_2(\text{s})$	- 986.1
calcium oxide	$\text{CaO}(\text{s})$	- 635.1
calcium sulphate	$\text{CaSO}_4(\text{s})$	- 1434.1
carbon dioxide	$\text{CO}_2(\text{g})$	- 393.5
carbon monoxide	$\text{CO}(\text{g})$	- 110.5
chromium(III) oxide	$\text{Cr}_2\text{O}_3(\text{s})$	- 1139.7
copper(I) oxide	$\text{Cu}_2\text{O}(\text{s})$	- 168.6
copper(II) oxide	$\text{CuO}(\text{s})$	- 157.3
copper(II) sulphate	$\text{CuSO}_4(\text{s})$	- 771.4
copper(I) sulphide	$\text{Cu}_2\text{S}(\text{s})$	- 79.5
copper(II) sulphide	$\text{CuS}(\text{s})$	- 53.1
ethane	$\text{C}_2\text{H}_6(\text{g})$	- 84.7
ethanoic acid (acetic acid)	$\text{CH}_3\text{COOH}(\text{l})$	- 484.5
ethanol	$\text{C}_2\text{H}_5\text{OH}(\text{l})$	- 277.1
ethene (ethylene)	$\text{C}_2\text{H}_4(\text{g})$	+ 52.3
ethyne (acetylene)	$\text{C}_2\text{H}_2(\text{g})$	+ 226.7
glucose	$\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$	- 1273.1
hydrogen bromide	$\text{HBr}(\text{g})$	- 36.4
hydrogen chloride	$\text{HCl}(\text{g})$	- 92.3
hydrogen fluoride	$\text{HF}(\text{g})$	- 271.1
hydrogen iodide	$\text{HI}(\text{g})$	+ 26.5
hydrogen perchlorate	$\text{HClO}_4(\text{l})$	- 40.6
hydrogen peroxide	$\text{H}_2\text{O}_2(\text{l})$	- 187.8
hydrogen sulphide	$\text{H}_2\text{S}(\text{g})$	- 20.6
iron(III) oxide	$\text{Fe}_2\text{O}_3(\text{s})$	- 824.2
iron(II, III) oxide (magnetite)	$\text{Fe}_3\text{O}_4(\text{s})$	- 1118.4
lead(II) bromide	$\text{PbBr}_2(\text{s})$	- 278.7
lead(II) chloride	$\text{PbCl}_2(\text{s})$	- 359.4
lead(II) oxide (red)	$\text{PbO}(\text{s})$	- 219.0
lead(IV) oxide	$\text{PbO}_2(\text{s})$	- 277.4
magnesium carbonate	$\text{MgCO}_3(\text{s})$	- 1095.8
magnesium chloride	$\text{MgCl}_2(\text{s})$	- 641.3
magnesium hydroxide	$\text{Mg}(\text{OH})_2(\text{s})$	- 924.5
magnesium oxide	$\text{MgO}(\text{s})$	- 601.7

STANDARD HEATS OF FORMATION AT 298.15 K (25°C) (continued)

NAME	FORMULA	ΔH_f° (kJ/mol)
magnesium sulphate	MgSO ₄ (s)	- 1284.9
manganese(II) oxide	MnO(s)	- 385.2
manganese(IV) oxide	MnO ₂ (s)	- 520.0
mercury(II) oxide (red)	HgO(s)	- 90.8
mercury(II) sulphide (red)	HgS(s)	- 58.2
methanal (formaldehyde)	CH ₂ O(g)	- 115.9
methane	CH ₄ (g)	- 74.8
methanoic acid (formic acid)	HCOOH(l)	- 424.7
methanol	CH ₃ OH(l)	- 239.0
nickel(II) oxide	NiO(s)	- 239.7
nitric acid	HNO ₃ (l)	- 174.1
nitrogen dioxide	NO ₂ (g)	+ 33.2
nitrogen monoxide	NO(g)	+ 90.2
octane	C ₈ H ₁₈ (l)	- 250.0
pentane	C ₅ H ₁₂ (l)	- 146.4
phosphorus pentachloride	PCl ₅ (s)	- 443.5
phosphorus trichloride (liquid)	PCl ₃ (l)	- 319.7
phosphorus trichloride (vapor)	PCl ₃ (g)	- 287.0
potassium bromide	KBr(s)	- 393.8
potassium chlorate	KClO ₃ (s)	- 397.7
potassium chloride	KCl(s)	- 436.7
potassium hydroxide	KOH(s)	- 424.8
propane	C ₃ H ₈ (g)	- 103.8
silicon dioxide	SiO ₂ (s)	- 910.9
silver bromide	AgBr(s)	- 100.4
silver chloride	AgCl(s)	- 127.1
silver iodide	AgI(s)	- 61.8
sodium bromide	NaBr(s)	- 361.1
sodium chloride	NaCl(s)	- 411.2
sodium hydroxide	NaOH(s)	- 425.6
sodium iodide	NaI(s)	- 287.8
sucrose	C ₁₂ H ₂₂ O ₁₁ (s)	- 2225.5
sulphur dioxide	SO ₂ (g)	- 296.8
sulphuric acid	H ₂ SO ₄ (l)	- 814.0
sulphur trioxide (liquid)	SO ₃ (l)	- 441.0
sulphur trioxide (vapor)	SO ₃ (g)	- 395.7
tin(II) chloride	SnCl ₂ (s)	- 325.1
tin(IV) chloride	SnCl ₄ (l)	- 511.3
tin(II) oxide	SnO(s)	- 285.8
tin(IV) oxide	SnO ₂ (s)	- 580.7
water (liquid)	H ₂ O(l)	- 285.8
water (vapor)	H ₂ O(g)	- 241.8
zinc oxide	ZnO(s)	- 348.3
zinc sulphide	ZnS(s)	- 206.0

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA or O																																																																																																																																																																																																																																										
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NOTE: The legend at right denotes the physical state of the elements at 101 kPa and 298.15 K (25°C)																																																																																																																																																																																																																																																								
3 6.94 lithium	4 9.01 beryllium	11 22.99 sodium	12 24.31 magnesium	19 39.10 potassium	20 40.08 calcium	21 44.96 scandium	22 47.90 titanium	23 50.94 vanadium	24 52.00 chromium	25 54.94 manganese	26 55.85 iron	27 58.93 cobalt	28 58.71 nickel	29 63.55 copper	30 65.38 zinc	31 69.74 gallium	32 72.59 germanium	33 74.92 arsenic	34 78.96 selenium	35 79.90 bromine	36 83.80 krypton	37 85.47 rubidium	38 87.62 strontium	39 88.91 yttrium	40 91.22 zirconium	41 92.91 niobium	42 95.94 molybdenum	43 98.91 technetium	44 101.07 ruthenium	45 102.91 rhodium	46 106.40 palladium	47 107.87 silver	48 112.41 cadmium	49 114.82 indium	50 118.69 tin	51 121.75 antimony	52 127.60 tellurium	53 126.90 iodine	54 131.30 xenon	55 132.91 cesium	56 137.33 barium	57 138.91 lanthanum	58 140.12 cerium	59 140.91 praseodymium	60 144.24 neodymium	61 145 promethium	62 150.35 samarium	63 151.96 europium	64 157.25 gadolinium	65 158.93 terbium	66 162.50 dysprosium	67 164.93 holmium	68 167.26 erbium	69 168.93 thulium	70 173.04 ytterbium	71 174.97 lutetium	72 175.04 hafnium	73 180.95 tantalum	74 183.85 tungsten	75 186.21 rhenium	76 190.20 osmium	77 192.22 iridium	78 195.09 platinum	79 196.97 gold	80 200.59 mercury	81 204.37 thallium	82 207.19 lead	83 208.98 bismuth	84 209 polonium	85 210 astatine	86 222 radon	87 223 francium	88 226.03 radium	89 227 actinium	90 232.04 thorium	91 231.04 protactinium	92 238.03 uranium	93 237.05 neptunium	94 244 plutonium	95 243 americium	96 247 curium	97 247 berkelium	98 251 californium	99 254 einsteinium	100 257 fermium	101 258 mandeleevium	102 259 nobelium	103 260 lawrencium	104 263 rutherfordium	105 260 hassium	106 263 seaborgium	107 263 bohrium	108 263 hassium	109 263 bohrium	110 263 bohrium	111 263 bohrium	112 263 bohrium	113 263 bohrium	114 263 bohrium	115 263 bohrium	116 263 bohrium	117 263 bohrium	118 263 bohrium	119 263 bohrium	120 263 bohrium	121 263 bohrium	122 263 bohrium	123 263 bohrium	124 263 bohrium	125 263 bohrium	126 263 bohrium	127 263 bohrium	128 263 bohrium	129 263 bohrium	130 263 bohrium	131 263 bohrium	132 263 bohrium	133 263 bohrium	134 263 bohrium	135 263 bohrium	136 263 bohrium	137 263 bohrium	138 263 bohrium	139 263 bohrium	140 263 bohrium	141 263 bohrium	142 263 bohrium	143 263 bohrium	144 263 bohrium	145 263 bohrium	146 263 bohrium	147 263 bohrium	148 263 bohrium	149 263 bohrium	150 263 bohrium	151 263 bohrium	152 263 bohrium	153 263 bohrium	154 263 bohrium	155 263 bohrium	156 263 bohrium	157 263 bohrium	158 263 bohrium	159 263 bohrium	160 263 bohrium	161 263 bohrium	162 263 bohrium	163 263 bohrium	164 263 bohrium	165 263 bohrium	166 263 bohrium	167 263 bohrium	168 263 bohrium	169 263 bohrium	170 263 bohrium	171 263 bohrium	172 263 bohrium	173 263 bohrium	174 263 bohrium	175 263 bohrium	176 263 bohrium	177 263 bohrium	178 263 bohrium	179 263 bohrium	180 263 bohrium	181 263 bohrium	182 263 bohrium	183 263 bohrium	184 263 bohrium	185 263 bohrium	186 263 bohrium	187 263 bohrium	188 263 bohrium	189 263 bohrium	190 263 bohrium	191 263 bohrium	192 263 bohrium	193 263 bohrium	194 263 bohrium	195 263 bohrium	196 263 bohrium	197 263 bohrium	198 263 bohrium	199 263 bohrium	200 263 bohrium	201 263 bohrium	202 263 bohrium	203 263 bohrium	204 263 bohrium	205 263 bohrium	206 263 bohrium	207 263 bohrium	208 263 bohrium	209 263 bohrium	210 263 bohrium	211 263 bohrium	212 263 bohrium	213 263 bohrium	214 263 bohrium	215 263 bohrium	216 263 bohrium	217 263 bohrium	218 263 bohrium	219 263 bohrium	220 263 bohrium	221 263 bohrium	222 263 bohrium	223 263 bohrium	224 263 bohrium	225 263 bohrium	226 263 bohrium	227 263 bohrium	228 263 bohrium	229 263 bohrium	230 263 bohrium	231 263 bohrium	232 263 bohrium	233 263 bohrium	234 263 bohrium	235 263 bohrium	236 263 bohrium	237 263 bohrium	238 263 bohrium	239 263 bohrium	240 263 bohrium	241 263 bohrium	242 263 bohrium	243 263 bohrium	244 263 bohrium	245 263 bohrium	246 263 bohrium	247 263 bohrium	248 263 bohrium	249 263 bohrium	250 263 bohrium	251 263 bohrium	252 263 bohrium	253 263 bohrium	254 263 bohrium	255 263 bohrium	256 263 bohrium	257 263 bohrium	258 263 bohrium	259 263 bohrium	260 263 bohrium	261 263 bohrium	262 263 bohrium	263 263 bohrium

PERIODIC CHART OF IONS

TABLE OF POLYATOMIC IONS					
acetate	CH_3COO^-	dichromate	$\text{Cr}_2\text{O}_7^{2-}$	dihydrogen phosphate	H_2PO_4^-
ammonium	NH_4^+	cyanide	CN^-	silicate	SiO_3^{2-}
benzoate	$\text{C}_6\text{H}_5\text{COO}^-$	hydroxide	OH^-	sulphate	SO_4^{2-}
borate	BO_3^{3-}	iodate	IO_3^-	sulphite	SO_3^{2-}
carbonate	CO_3^{2-}	nitrate	NO_3^-	hydrogen sulphide	HS^-
hydrogen carbonate	HCO_3^-	nitrite	NO_2^-	hydrogen sulphate	HSO_4^-
chlorate	ClO_3^-	oxalate	OOCOCO^{2-}	hydrogen sulphite	HSO_3^-
hypochlorite	ClO^-	permanganate	MnO_4^-	thiocyanate	SCN^-
chromate	CrO_4^{2-}	phosphate	PO_4^{3-}	thiosulphate	$\text{S}_2\text{O}_3^{2-}$
		hydrogen phosphate	HPO_4^{2-}		

1	H ⁺ hydrogen	2	He helium
3	Li ⁺ lithium	4	Be ²⁺ beryllium
5	B boron	6	C carbon
7	N nitrogen	8	O ²⁻ oxide
9	F ⁻ fluorine	10	Ne neon
11	Na ⁺ sodium	12	Mg ²⁺ magnesium
13	Al ³⁺ aluminum	14	Si silicon
15	P ³⁻ phosphorus	16	S ²⁻ sulphide
17	Cl ⁻ chlorine	18	Ar argon
19	K ⁺ potassium	20	Ca ²⁺ calcium
21	Sc scandium	22	Ti titanium
23	V vanadium	24	Cr chromium
25	Mn manganese	26	Fe iron
27	Co cobalt	28	Ni nickel
29	Cu copper	30	Zn zinc
31	Ga gallium	32	Ge germanium
33	As arsenic	34	Se selenium
35	Br bromine	36	Kr krypton
37	Rb rubidium	38	Sr strontium
39	Y yttrium	40	Zr zirconium
41	Nb niobium	42	Mo molybdenum
43	Tc technetium	44	Ru ruthenium
45	Rh rhodium	46	Pd palladium
47	Ag silver	48	Cd cadmium
49	In indium	50	Sn tin
51	Sb antimony	52	Te tellurium
53	I ⁻ iodine	54	Xe xenon
55	Cs cesium	56	Ba ²⁺ barium
57-71		58	Ra ²⁺ radium
72	Hf hafnium	73	Ta tantalum
74	W tungsten	75	Re rhenium
76	Os osmium	77	Ir iridium
78	Pt platinum	79	Au gold
80	Hg mercury	81	Tl thallium
82	Pb lead	83	Bi bismuth
84	Po polonium	85	At astatine
86	Rn radon	87	Fr francium
88		89-103	
104	Rf rutherfordium	105	Ha hahnium
106		107	

atomic number	→	26	Fe ³⁺	← ion charge
			iron(III)	← stock name
			Fe ²⁺	← symbol
			iron(II)	

57	La ³⁺ lanthanum	58	Ce ³⁺ cerium	59	Pr ³⁺ praseodymium	60	Nd ³⁺ neodymium	61	Pm ³⁺ promethium	62	Sm ³⁺ samarium(III)	63	Eu ³⁺ europium(III)	64	Gd ³⁺ gadolinium	65	Tb ³⁺ terbium	66	Dy ³⁺ dysprosium	67	Ho ³⁺ holmium	68	Er ³⁺ erbium	69	Tm ³⁺ thulium	70	Yb ³⁺ ytterbium(III)	71	Lu ³⁺ lutetium
89	Ac ³⁺ actinium	90	Th ⁴⁺ thorium	91	Pa ⁵⁺ protactinium(V)	92	U ⁶⁺ uranium(VI)	93	Np ⁵⁺ neptunium	94	Pu ⁴⁺ plutonium(IV)	95	Am ³⁺ americium(III)	96	Cm ³⁺ curium	97	Bk ³⁺ berkelium(III)	98	Cf ³⁺ californium	99	Es ³⁺ einsteinium	100	Fm ³⁺ fermium	101	Md ²⁺ mendelevium(II)	102	No ²⁺ nobelium(II)	103	Lr ³⁺ lawrencium

ACID-BASE INDICATORS AT 298.15 K (25°C)

INDICATOR	SUGGESTED ABBREVIATION	pH RANGE	COLOR CHANGE AS pH INCREASES
methyl violet	HMv	0.0 - 1.6	yellow to blue
thymol blue	H ₂ Tb HTb ⁻	1.2 - 2.8 8.0 - 9.6	red to yellow yellow to blue
orange IV	HOr	1.4 - 2.8	red to yellow
methyl orange	HMo	3.2 - 4.4	red to yellow
bromocresol green	HBg	3.8 - 5.4	yellow to blue
litmus	HLt	4.5 - 8.3	red to blue
methyl red	HMr	4.8 - 6.0	red to yellow
chlorophenol red	HCh	5.2 - 6.8	yellow to red
bromothymol blue	HBb	6.0 - 7.6	yellow to blue
phenol red	HPr	6.6 - 8.0	yellow to red
phenolphthalein	HPh	8.2 - 10.0	colorless to pink
thymolphthalein	HTh	9.4 - 10.6	colorless to blue
alizarin yellow R	HAY	10.1 - 12.0	yellow to red
indigo carmine	HIc	11.4 - 13.0	blue to yellow
1,3,5-trinitrobenzene	HNb	12.0 - 14.0	colorless to orange

RELATIVE STRENGTHS OF 0.10 mol/L ACIDS AND BASES AT 298.15 K (25°C)*

% DISSOCIATION WITH WATER	ACID		CONJUGATE	
	NAME	FORMULA	BASE	K_a
100	perchloric acid	$\text{HClO}_4(\text{aq})$	$\text{ClO}_4^- (\text{aq})$	very large
100	hydroiodic acid	$\text{HI}(\text{aq})$	$\text{I}^- (\text{aq})$	3.2×10^9
100	hydrobromic acid	$\text{HBr}(\text{aq})$	$\text{Br}^- (\text{aq})$	1.0×10^9
100	hydrochloric acid	$\text{HCl}(\text{aq})$	$\text{Cl}^- (\text{aq})$	1.3×10^6
100	sulphuric acid	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{HSO}_4^- (\text{aq})$	1.0×10^3
100	nitric acid	$\text{HNO}_3(\text{aq})$	$\text{NO}_3^- (\text{aq})$	2.4×10^1
100	hydronium ion	$\text{H}_3\text{O}^+ (\text{aq})$	$\text{H}_2\text{O}(\text{l})$	—
51	oxalic acid	$\text{HOOC}\text{COOH}(\text{aq})$	$\text{HOOC}\text{COO}^- (\text{aq})$	5.4×10^{-2}
30	sulphurous acid ($\text{SO}_2 + \text{H}_2\text{O}$)	$\text{H}_2\text{SO}_3(\text{aq})$	$\text{HSO}_3^- (\text{aq})$	1.3×10^{-2}
27	hydrogen sulphate ion	$\text{HSO}_4^- (\text{aq})$	$\text{SO}_4^{2-} (\text{aq})$	1.0×10^{-2}
23	phosphoric acid	$\text{H}_3\text{PO}_4(\text{aq})$	$\text{H}_2\text{PO}_4^- (\text{aq})$	7.0×10^{-3}
8.2	nitrous acid	$\text{HNO}_2(\text{aq})$	$\text{NO}_2^- (\text{aq})$	7.2×10^{-4}
7.8	hydrofluoric acid	$\text{HF}(\text{aq})$	$\text{F}^- (\text{aq})$	6.6×10^{-4}
4.1	methanoic acid	$\text{HCOOH}(\text{aq})$	$\text{HCOO}^- (\text{aq})$	1.8×10^{-4}
	methyl orange	$\text{HMo}(\text{aq})$	$\text{Mo}^- (\text{aq})$	$\sim \times 10^{-4}$
2.3	hydrogen oxalate ion	$\text{HOOC}\text{COO}^- (\text{aq})$	$\text{OOC}\text{COO}^{2-} (\text{aq})$	5.4×10^{-5}
1.3	ethanoic (acetic) acid	$\text{CH}_3\text{COOH}(\text{aq})$	$\text{CH}_3\text{COO}^- (\text{aq})$	1.8×10^{-5}
0.21	carbonic acid ($\text{CO}_2 + \text{H}_2\text{O}$)	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{HCO}_3^- (\text{aq})$	4.4×10^{-7}
	bromothymol blue	$\text{HBb}(\text{aq})$	$\text{Bb}^- (\text{aq})$	$\sim \times 10^{-7}$
0.10	hydrosulphuric acid	$\text{H}_2\text{S}(\text{aq})$	$\text{HS}^- (\text{aq})$	1.1×10^{-7}
7.9×10^{-2}	dihydrogen phosphate ion	$\text{H}_2\text{PO}_4^- (\text{aq})$	$\text{HPO}_4^{2-} (\text{aq})$	6.3×10^{-8}
7.9×10^{-2}	hydrogen sulphite ion	$\text{HSO}_3^- (\text{aq})$	$\text{SO}_3^{2-} (\text{aq})$	6.2×10^{-8}
5.4×10^{-2}	hypochlorous acid	$\text{HOCl}(\text{aq})$	$\text{OCl}^- (\text{aq})$	2.9×10^{-8}
	phenolphthalein	$\text{HPh}(\text{aq})$	$\text{Ph}^- (\text{aq})$	$\sim \times 10^{-10}$
7.9×10^{-3}	hydrocyanic acid	$\text{HCN}(\text{aq})$	$\text{CN}^- (\text{aq})$	6.2×10^{-10}
7.6×10^{-3}	boric acid	$\text{H}_3\text{BO}_3(\text{aq})$	$\text{H}_2\text{BO}_3^- (\text{aq})$	5.8×10^{-10}
7.6×10^{-3}	ammonium ion	$\text{NH}_4^+ (\text{aq})$	$\text{NH}_3(\text{aq})$	5.8×10^{-10}
2.2×10^{-3}	hydrogen carbonate ion	$\text{HCO}_3^- (\text{aq})$	$\text{CO}_3^{2-} (\text{aq})$	4.7×10^{-11}
2.0×10^{-4}	hydrogen phosphate ion	$\text{HPO}_4^{2-} (\text{aq})$	$\text{PO}_4^{3-} (\text{aq})$	4.2×10^{-13}
1.4×10^{-4}	dihydrogen borate ion	$\text{H}_2\text{BO}_3^- (\text{aq})$	$\text{HBO}_3^{2-} (\text{aq})$	1.8×10^{-13}
1.1×10^{-4}	hydrogen sulphide ion	$\text{HS}^- (\text{aq})$	$\text{S}^{2-} (\text{aq})$	1.3×10^{-13}
4.0×10^{-5}	hydrogen borate ion	$\text{HBO}_3^{2-} (\text{aq})$	$\text{BO}_3^{3-} (\text{aq})$	1.6×10^{-14}
	water (55.5 mol/L)	$\text{H}_2\text{O}(\text{l})$	$\text{OH}^- (\text{aq})$	—
	hydroxide ion	$\text{OH}^- (\text{aq})$	$\text{O}^{2-} (\text{aq})$	—

* except for indicators, which are normally used at lower concentration

SOLUBILITY OF SOME COMMON IONIC COMPOUNDS IN WATER AT 298.15 K (25°C)

ION	Group IA NH_4^+ $\text{H}^+ (\text{H}_3\text{O}^+)$	ClO_3^- NO_3^- ClO_4^-	CH_3COO^-	Cl^- Br^- I^-	SO_4^{2-}	S^{2-}	OH^-	PO_4^{3-} SO_3^{2-} CO_3^{2-}
Solubility greater than or equal to 0.1 mol/L (very soluble)	all	all	most	most	most	Group IA Group IIA NH_4^+	Group IA NH_4^+ Sr^{2+} Ba^{2+} Ti^+	Group IA NH_4^+
Solubility less than 0.1 mol/L (slightly soluble)	none	none	Ag^+ Hg^+	Ag^+ Pb^{2+} Hg^+ Cu^+ Ti^+	Ca^{2+} Sr^{2+} Ba^{2+} Ra^{2+} Pb^{2+} Ag^+	most	most	most

COLOR CHART OF COMMON AQUEOUS IONS

ION	SYMBOL	COLOR
chromate	CrO_4^{2-}	yellow
chromium(III)	Cr^{3+}	green
chromium(II)	Cr^{2+}	blue
cobalt(II)	Co^{2+}	pink
copper(I)	Cu^+	green
copper(II)	Cu^{2+}	blue
dichromate	$\text{Cr}_2\text{O}_7^{2-}$	orange
iron(II)	Fe^{2+}	pale green
iron(III)	Fe^{3+}	pale yellow
manganese(II)	Mn^{2+}	pale pink
permanganate	MnO_4^-	purple

STANDARD ELECTRODE POTENTIALS FOR 1.0 mol/L SOLUTIONS AT 298.15 K (25°C)

Reduction Half-Reaction		E° (V)
$F_2(g) + 2e^-$	$\longrightarrow 2F^-(aq)$	+ 2.87
$H_2O_2(l) + 2H^+(aq) + 2e^-$	$\longrightarrow 2H_2O(l)$	+ 1.78
$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$	$\longrightarrow PbSO_4(s) + 2H_2O(l)$	+ 1.69
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	+ 1.51
$Au^{3+}(aq) + 3e^-$	$\longrightarrow Au(s)$	+ 1.50
$ClO_4^-(aq) + 8H^+(aq) + 8e^-$	$\longrightarrow Cl^-(aq) + 4H_2O(l)$	+ 1.39
$Cl_2(g) + 2e^-$	$\longrightarrow 2Cl^-(aq)$	+ 1.36
$2HNO_2(aq) + 4H^+(aq) + 4e^-$	$\longrightarrow N_2O(g) + 3H_2O(l)$	+ 1.30
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$	$\longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	+ 1.23
$O_2(g) + 4H^+(aq) + 4e^-$	$\longrightarrow 2H_2O(l)$	+ 1.23
$MnO_2(s) + 4H^+(aq) + 2e^-$	$\longrightarrow Mn^{2+}(aq) + 2H_2O(l)$	+ 1.22
$Br_2(l) + 2e^-$	$\longrightarrow 2Br^-(aq)$	+ 1.07
$Hg^{2+}(aq) + 2e^-$	$\longrightarrow Hg(l)$	+ 0.85
$ClO^-(aq) + H_2O(l) + 2e^-$	$\longrightarrow Cl^-(aq) + 2OH^-(aq)$	+ 0.84
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	+ 0.80
$NO_3^-(aq) + 2H^+(aq) + e^-$	$\longrightarrow NO_2(g) + H_2O(l)$	+ 0.80
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	+ 0.77
$O_2(g) + 2H^+(aq) + 2e^-$	$\longrightarrow H_2O_2(l)$	+ 0.70
$I_2(s) + 2e^-$	$\longrightarrow 2I^-(aq)$	+ 0.54
$O_2(g) + 2H_2O(l) + 4e^-$	$\longrightarrow 4OH^-(aq)$	+ 0.40
$Cu^{2+}(aq) + 2e^-$	$\longrightarrow Cu(s)$	+ 0.34
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$	$\longrightarrow H_2SO_3(aq) + H_2O(l)$	+ 0.17
$Sn^{4+}(aq) + 2e^-$	$\longrightarrow Sn^{2+}(aq)$	+ 0.15
$S(s) + 2H^+(aq) + 2e^-$	$\longrightarrow H_2S(aq)$	+ 0.14
$AgBr(s) + e^-$	$\longrightarrow Ag(s) + Br^-(aq)$	+ 0.07
$2H^+(aq) + 2e^-$	$\longrightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^-$	$\longrightarrow Pb(s)$	- 0.13
$Sn^{2+}(aq) + 2e^-$	$\longrightarrow Sn(s)$	- 0.14
$AgI(s) + e^-$	$\longrightarrow Ag(s) + I^-(aq)$	- 0.15
$Ni^{2+}(aq) + 2e^-$	$\longrightarrow Ni(s)$	- 0.26
$Co^{2+}(aq) + 2e^-$	$\longrightarrow Co(s)$	- 0.28
$PbSO_4(s) + 2e^-$	$\longrightarrow Pb(s) + SO_4^{2-}(aq)$	- 0.36
$Se(s) + 2H^+(aq) + 2e^-$	$\longrightarrow H_2Se(aq)$	- 0.40
$Cd^{2+}(aq) + 2e^-$	$\longrightarrow Cd(s)$	- 0.40
$Cr^{3+}(aq) + e^-$	$\longrightarrow Cr^{2+}(aq)$	- 0.41
$Fe^{2+}(aq) + 2e^-$	$\longrightarrow Fe(s)$	- 0.45
$NO_2^-(aq) + H_2O(l) + e^-$	$\longrightarrow NO(g) + 2OH^-(aq)$	- 0.46
$Ag_2S(s) + 2e^-$	$\longrightarrow 2Ag(s) + S^{2-}(aq)$	- 0.69
$Zn^{2+}(aq) + 2e^-$	$\longrightarrow Zn(s)$	- 0.76
$Te(s) + 2H^+(aq) + 2e^-$	$\longrightarrow H_2Te(aq)$	- 0.79
$2H_2O(l) + 2e^-$	$\longrightarrow H_2(g) + 2OH^-(aq)$	- 0.83
$Cr^{2+}(aq) + 2e^-$	$\longrightarrow Cr(s)$	- 0.91
$Se(s) + 2e^-$	$\longrightarrow Se^{2-}(aq)$	- 0.92
$SO_4^{2-}(aq) + H_2O(l) + 2e^-$	$\longrightarrow SO_3^{2-}(aq) + 2OH^-(aq)$	- 0.93
$Te(s) + 2e^-$	$\longrightarrow Te^{2-}(aq)$	- 1.14
$Al^{3+}(aq) + 3e^-$	$\longrightarrow Al(s)$	- 1.66
$Mg^{2+}(aq) + 2e^-$	$\longrightarrow Mg(s)$	- 2.37
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	- 2.71
$Ca^{2+}(aq) + 2e^-$	$\longrightarrow Ca(s)$	- 2.87
$Ba^{2+}(aq) + 2e^-$	$\longrightarrow Ba(s)$	- 2.91
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	- 3.04

↑ INCREASING STRENGTH OF OXIDIZING AGENTS

↓ INCREASING STRENGTH OF REDUCING AGENTS

NLC-BNC.



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